

APPENDIX G

DEVELOPMENT OF AIR EMISSIONS INVENTORIES FOR NONROAD MODEL CATEGORY MOBILE SOURCES (TASK 3)



Development of Air Emissions Inventories for NONROAD Model Category Mobile Sources (Task 3)

Final Report

TCEQ Contract No. 582-15-50416

Work Order No. 582-15-51606-03

Project No. 2015-08

Task 3

Prepared for:

Texas Commission on Environmental Quality
Air Quality Division

Prepared by:

Eastern Research Group, Inc.

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March 31, 2015

LIST OF ACRONYMS

| | |
|-------------------|---|
| AACOG | Alamo Area Council of Governments |
| CNG | Compressed Natural Gas |
| CO | Carbon Monoxide |
| CO ₂ | Carbon Dioxide |
| DCE | Diesel Construction Equipment |
| DFW | Dallas-Fort Worth |
| EDA | Equipment Data Associates |
| EPA | Environmental Protection Agency |
| ERG | Eastern Research Group |
| HGB | Houston-Galveston-Brazoria |
| HP | Horsepower |
| LPG | Liquefied Petroleum Gas |
| MHC | McGraw Hill Corporation |
| NCDC | National Climatic Data Center |
| NH ₃ | Ammonia |
| NOAA | National Oceanic and Atmospheric Administration |
| NO _x | Oxides of Nitrogen |
| PM ₁₀ | Particulate Matter < 10 microns in diameter |
| PM _{2.5} | Particulate Matter < 2.5 microns in diameter |
| REMI | Regional Economic Models, Inc. |
| RFG | Reformulated Gasoline |
| RTF | Rough Terrain Forklift |
| SCC | Source Classification Code |
| SIP | State Implementation Plan |
| SIP | Spark Ignition |
| SO ₂ | Sulfur Dioxide |
| TCEQ | Texas Commission on Environmental Quality |
| TexN | Texas NONROAD Model |
| TPD | Tons Per Day |
| TWC | Three-way Catalyst |
| TX | Texas |
| TxDOT | Texas Department of Transportation |
| TxLED | Texas Low Emission Diesel |
| US EPA | United States Environmental Protection Agency |
| VOC | Volatile Organic Compounds |

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1.0 Introduction

The purpose of Task 3 of this Work Order was to develop a set of emissions inventories for all NONROAD model category mobile sources for selected years, estimating both controlled and uncontrolled emissions, for the Dallas-Fort Worth nine-county and Houston-Galveston-Brazoria eight-county 1997 eight-hour ozone nonattainment areas.

The TexN model is a tool for developing emissions estimates for nonroad mobile sources in Texas for the mobile source categories under the United States Environmental Protection Agency's (EPA) NONROAD model. TexN has a user-friendly graphical user interface and stores data in a MySQL database. TexN executes EPA's NONROAD2008a model and allows TCEQ staff to replace EPA default data with local specific data. Currently, the TexN model is used by TCEQ staff, local air quality planning agencies, and other nonroad mobile stakeholders in order to facilitate the use of locally developed activity and population data for nonroad mobile sources, and to standardize the emissions estimation methodologies among the different submitting agencies in Texas. The TCEQ supplies all interested parties with the latest model, which reflects TCEQ updates to specific data, and coordinates the integration of all local changes. The emissions estimates developed using this integrated model are used for state implementation plan modeling efforts, the EPA's reporting requirements, trends analyses, and air quality modeling purposes.

Using the latest version of the Texas NONROAD (TexN) model¹, which incorporates all of the latest available data updates, ERG developed both controlled and uncontrolled average summer weekday emissions for VOC and NOX for the analysis years 2012, 2014, 2017, 2020, 2023, 2026, and 2028 for the DFW nine-county and HGB eight-county 1997 eight-hour ozone nonattainment areas.

This report presents the summaries of the emissions modeling results and provides a very brief summary from where each of the critical model inputs were derived from. Please note that TCEQ has a number of reports that have been generated over the evolution of the TexN model that go into greater detail about the development of each of the model inputs and subsequent data updates.

2.0 Input Data Sources

The following sections are meant only to provide a very brief summary of where the TexN inputs were derived from. Additional detail may be found in the numerous reports for studies conducted by TCEQ throughout the life of TexN.

¹ TexN version 1.7.1

2.1 Equipment Population, Allocation, and Activity Data²

The TCEQ and others have conducted several studies over the years to collect region specific population and activity data for selected non-road engine categories, in order to improve upon NONROAD default estimates. Working with TCEQ staff, ERG compiled a comprehensive list of the most recent data developed for different equipment types and regions of the State for inclusion in the TexN model. The sources of the data for each equipment type and region are presented in Tables 1 - 6 below. The methods used to estimate equipment populations and activity levels can be quite complex; in depth discussions of the various methodologies used are provided in the referenced studies.

Table 1. Sources of Equipment Population Data

| Equipment Types | Region | Data Source |
|---|--|---|
| Diesel Construction Equipment > 25 hp | Dallas-Fort Worth (DFW) 9-county nonattainment area ³ | Eastern Research Group, Ozone Science and Air Modeling Research Project H43T163: Diesel Construction Equipment Activity and Emissions Estimates for the Dallas/Ft. Worth Region, prepared for The Houston Advanced Research Center, August 31, 2005 |
| Diesel Construction Equipment > 25 hp, except HGB ⁴ cranes | Statewide excluding 9-county DFW area | Eastern Research Group, Nonroad Ammonia Emissions Inventory Development, prepared for Texas Commission on Environmental Quality, November 24, 2006 |
| Mining and Quarry, Special Trades, Scrap and Recycling, Utility, Rough Terrain Forklifts (RTFs), and Skid Steer Loaders Diesel Construction Equipment | Statewide | Eastern Research Group, Update of Diesel Construction Equipment Emissions Estimates for the State of Texas, Prepared for TCEQ, August 31, 2008. |
| Mining and Quarry Diesel Construction Equipment | Alamo Area Council of Governments area | AACOG Chapter 2, Table 2-27, 2005 Non-road Emissions Inventory |

² Information taken from TexN User's Guide unless otherwise noted. *Eastern Research Group, Texas NONROAD (TexN) Model Version 1.0 User's Guide, Work Order No. 582-7-84003-FY-08-09, August 18, 2008.*

³ Includes Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant Counties.

⁴ Includes Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties.

| Equipment Types | Region | Data Source |
|--|---|---|
| Heavy Highway Diesel Construction Equipment | Statewide | Eastern Research Group, Update of DCE Emission Estimates for the State of Texas Phase I and Phase II, July 31, 2009 and Eastern Research Group, Update of Heavy-Highway Portion of Diesel Construction Equipment Inventory Using New Data Sources, prepared for TCEQ, July 15, 2014. |
| Diesel Cranes | Houston-Galveston-Brazoria (HGB) nonattainment area | Eastern Research Group, Nonroad Mobile Source Emissions Inventory Development for the Houston-Galveston-Brazoria Area, submitted to the Houston-Galveston Area Council, July 28, 2006 |
| LPG Forklifts | DFW 9-county area and HGB nonattainment areas | Eastern Research Group, Data Collection, Sampling and Emissions Inventory Preparation Plan for Selected Commercial and Industrial Equipment: Phase II, Final Report, prepared for the Texas Commission on Environmental Quality, August 31, 2005 |
| Terminal Tractors and Transportation Refrigeration Units | DFW 9-county nonattainment area | Eastern Research Group, Data Collection, Sampling and Emissions Inventory Preparation Plan for Selected Commercial and Industrial Equipment: Phase II, Final Report, prepared for the Texas Commission on Environmental Quality, August 31, 2005 |
| Transportation Refrigeration Units | HGB nonattainment area | Eastern Research Group, Nonroad Mobile Source Emissions Inventory Development for the Houston-Galveston-Brazoria Area, submitted to the Houston-Galveston Area Council, July 28, 2006 |
| Commercial Lawn and Garden | Statewide | Eastern Research Group, Development of Commercial Lawn and Garden Emissions Estimates for the State of Texas and Selected Metropolitan Areas, prepared for Texas Commission on Environmental Quality, November 24, 2003 |
| Recreational Marine | Statewide (except HGB area) | Eastern Research Group, Recreational Marine Emissions Inventory, prepared for the Texas Commission on Environmental Quality, August 28, 2002 |

| Equipment Types | Region | Data Source |
|-------------------------------------|------------------------|---|
| Recreational Marine | HGB nonattainment area | E.H. Pechan & Associates, Development of 2007 Recreational Marine Emissions Inventory: Spatial and Temporal Allocation In the Houston-Galveston-Brazoria 8-County Area, 2008 ⁵ |
| Agricultural Equipment | Statewide | E.H. Pechan & Associates, Inc. |
| All remaining equipment – see below | See below | NONROAD defaults - User's Guide for the Final NONROAD2005 Model, EPA420-R-05-013, December 2005 |

Equipment population estimates were taken from NONROAD defaults for the following equipment categories.

- Commercial – all equipment/fuel types
- Logging – all equipment/fuel types
- Railroad – all equipment/fuel types
- Recreational vehicles – all equipment/fuel types
- Residential lawn and garden – all equipment/fuel types
- Industrial – all equipment/fuel types excluding LPG forklifts in DFW and HGB, Transportation Refrigeration Units and Terminal Tractors in DFW
- Construction and Mining – all gasoline, LPG, CNG
- Construction and Mining – diesel < 25 hp
- Construction and Mining – diesel > 25 hp:
 - Tampers/Rammers
 - Plate Compactors
 - Signal Boards/Light Plants
 - Concrete/Industrial Saws
 - Crushing/Processing Equipment
 - Cement/Mortar Mixers
 - Dumpers/Tenders
 - Off-Highway Tractors
 - Other Construction Equipment

Table 2. Spatial Allocation Surrogates for Diesel Construction Equipment

| Sector | Surrogate |
|-----------------------------------|--|
| Agricultural | Dollar value outputs from Texas Regional Economic Models, Inc. (REMI) model* |
| Boring and Drilling Equipment | EDA data and dollar value outputs from TX REMI model* |
| Brick and Stone Operations | Dollar value outputs from TX REMI model* |
| City and County Road Construction | Project Dollar Value from Reed Construction Data |

⁵ E.H. Pechan & Associates, Development of 2007 Recreational Marine Emissions Inventory: Spatial and Temporal Allocation in the Houston-Galveston-Brazoria 8-County Area, 2008.

| Sector | Surrogate |
|---|--|
| Commercial Construction | Building footprint data from McGraw Hill Corporation (MHC) |
| Concrete Operations | Dollar value outputs from TX REMI model* |
| County-Owned Construction Equipment | County level census projections |
| Cranes | EDA data and dollar value outputs from TX REMI model* |
| Heavy Highway Construction | Project lane-mile data by county from TxDOT |
| Landfill Operations | Landfill disposal volumes from TCEQ |
| Landscaping Activities | Dollar value outputs from TX REMI model* |
| Manufacturing Operations | Dollar value outputs from TX REMI model* |
| Mining and Quarry Operations | Million Tons of Coal Production and Annual non-office employee hours respectively (2007) ⁶ |
| Municipal-Owned Construction Equipment | County level census projections |
| Transportation Sales/Services | Dollar value outputs from TX REMI model* |
| Residential Construction | County-level housing permit data from the Texas A&M Real Estate Center for 1980 through 2013; County-level census projections from the Texas State Data Center for 2014 through 2050; Housing start for the southern region of the country from the U.S. Census Bureau prior to 1980 |
| Rough Terrain Forklifts, Special Trades Construction, and Trenchers | 2007 Economy.com ⁶ |
| Scrap/Recycling Operations | USA Data© (2007) ⁶ |
| Skid Steer Loaders | EDA data and dollar value outputs from TX REMI model* |
| TxDOT Construction Equipment | None – TxDOT provided complete county-level population data |
| Utility Construction | Project Dollar value from Reed Construction Data and MHC |

* State level extrapolation and county allocation using 9-county DFW population as basis.

Table 3. Sources of Geographic Allocation Data (Non-DCE)

| Equipment Types | Region | Data Source |
|------------------------|---|--|
| LPG Forklifts | 9-county DFW area and HGB nonattainment areas | Eastern Research Group, Data Collection, Sampling and Emissions Inventory Preparation Plan for Selected Commercial and Industrial Equipment: Phase II, Final Report, prepared for the Texas Commission on Environmental Quality, August 31, 2005 |

⁶ Eastern Research Group, Update of Diesel Construction Equipment Emissions Estimates for the State of Texas, Prepared for TCEQ, August 31, 2008.

| Equipment Types | Region | Data Source |
|--|---------------------------------|--|
| Terminal Tractors and Transportation Refrigeration Units | 9-county DFW nonattainment area | Eastern Research Group, Data Collection, Sampling and Emissions Inventory Preparation Plan for Selected Commercial and Industrial Equipment: Phase II, Final Report, prepared for the Texas Commission on Environmental Quality, August 31, 2005 |
| Transportation Refrigeration Units | HGB nonattainment area | Eastern Research Group, Nonroad Mobile Source Emissions Inventory Development for the Houston-Galveston-Brazoria Area, submitted to the Houston-Galveston Area Council, July 28, 2006 |
| Commercial Lawn and Garden | Statewide | Eastern Research Group, Development of Commercial Lawn and Garden Emissions Estimates for the State of Texas and Selected Metropolitan Areas, prepared for Texas Commission on Environmental Quality, November 24, 2003 |
| Recreational Marine | Statewide | Eastern Research Group, Recreational Marine Emissions Inventory, prepared for the Texas Commission on Environmental Quality, August 28, 2002 |
| All remaining equipment – see below | See below | NONROAD defaults - User's Guide for the Final NONROAD2005 Model, EPA420-R-05-013, December 2005 |

Geographic allocation surrogates were taken from NONROAD defaults for the following equipment categories.

- Agricultural – all equipment
- Commercial – all equipment
- Logging – all equipment
- Railroad – all equipment
- Recreational vehicles – all equipment
- Residential lawn and garden – all equipment
- Industrial – all equipment/fuel types excluding LPG forklifts in DFW and HGB, TRUs and Terminal Tractors in DFW

Table 4. Sources of Equipment Activity Data

| Equipment Types | Region | Data Source |
|------------------------|------------------------|---|
| Diesel Cranes | HGB nonattainment area | Eastern Research Group, Nonroad Mobile Source Emissions Inventory Development for the Houston-Galveston-Brazoria Area, submitted to the Houston-Galveston Area Council, July 28, 2006 |

| Equipment Types | Region | Data Source |
|---|--|---|
| Diesel Construction Equipment > 25 hp | 9-county DFW nonattainment area | Eastern Research Group, Ozone Science and Air Modeling Research Project H43T163: Diesel Construction Equipment Activity and Emissions Estimates for the Dallas/Ft. Worth Region, prepared for The Houston Advanced Research Center, August 31, 2005 |
| Diesel Construction Equipment > 25 hp | Remainder of State, except HGB cranes | Eastern Research Group, Nonroad Ammonia Emissions Inventory Development, prepared for Texas Commission on Environmental Quality, November 24, 2006 |
| LPG Forklifts | 9-county DFW and HGB nonattainment areas | Eastern Research Group, Data Collection, Sampling and Emissions Inventory Preparation Plan for Selected Commercial and Industrial Equipment: Phase II, Final Report, prepared for the Texas Commission on Environmental Quality, August 31, 2005 |
| Terminal Tractors and Transportation Refrigeration Units | 9-county DFW nonattainment area | Eastern Research Group, Data Collection, Sampling and Emissions Inventory Preparation Plan for Selected Commercial and Industrial Equipment: Phase II, Final Report, prepared for the Texas Commission on Environmental Quality, August 31, 2005 |
| Transportation Refrigeration Units | HGB nonattainment area | Eastern Research Group, Nonroad Mobile Source Emissions Inventory Development for the Houston-Galveston-Brazoria Area, submitted to the Houston-Galveston Area Council, July 28, 2006 |
| Commercial Lawn and Garden | Statewide | Eastern Research Group, Development of Commercial Lawn and Garden Emissions Estimates for the State of Texas and Selected Metropolitan Areas, prepared for Texas Commission on Environmental Quality, November 24, 2003 |
| All remaining equipment – see equipment population list above | See equipment population list above | NONROAD defaults - User's Guide for the Final NONROAD2005 Model, EPA420-R-05-013, December 2005 |

Table 5. Activity Surrogates for Construction Equipment

| Sector | Primary Estimation Method |
|-------------------------------------|--|
| Agricultural | Industry expert profiles |
| Boring and Drilling Equipment | Industry expert profiles |
| Brick and Stone Operations | Industry expert profiles |
| City and County Road Construction | Reed Construction profile |
| Commercial Construction | Square feet of installed building space from MHC |
| Concrete Operations | Industry expert profiles |
| County-Owned Construction Equipment | Survey findings from HARC study |

| Sector | Primary Estimation Method |
|--|---|
| Cranes | Industry expert profiles |
| Heavy Highway Construction | Survey findings from H-GAC study |
| Landfill Operations | Survey profile from TCEQ study |
| Landscaping Activities | Industry expert profiles |
| Manufacturing Operations | Industry expert profiles |
| Municipal-Owned Construction Equipment | Survey findings from HARC study |
| Transportation Sales/Services | Industry expert profiles |
| Residential Construction | Single family housing construction profile |
| Rough Terrain Forklifts | Industry expert profiles |
| Scrap/Recycling Operations | Industry expert profiles |
| Skid Steer Loaders | Industry expert profiles |
| Special Trades Construction | Industry expert profiles |
| Trenchers | Industry expert profiles |
| TxDOT Construction Equipment | Engine clock hours provided by TxDOT |
| Utility Construction | Linear feet installed from Reed Construction Data |

Table 6. Sources of Temporal Allocation Factors

| Equipment Types | Region | Data Source |
|---|--|---|
| Diesel Construction Equipment > 25 hp | 9-county DFW nonattainment area | Eastern Research Group, Ozone Science and Air Modeling Research Project H43T163: Diesel Construction Equipment Activity and Emissions Estimates for the Dallas/Ft. Worth Region, prepared for The Houston Advanced Research Center, August 31, 2005 |
| Diesel Construction Equipment > 25 hp | Statewide excluding 9-county DFW area | Eastern Research Group, Nonroad Ammonia Emissions Inventory Development, prepared for Texas Commission on Environmental Quality, November 24, 2006 |
| LPG Forklifts | 9-county DFW and HGB nonattainment areas | Eastern Research Group, Data Collection, Sampling and Emissions Inventory Preparation Plan for Selected Commercial and Industrial Equipment: Phase II, Final Report, prepared for the Texas Commission on Environmental Quality, August 31, 2005 |
| All remaining equipment – see equipment population list above | See equipment population list above | NONROAD defaults - User's Guide for the Final NONROAD2005 Model, EPA420-R-05-013, December 2005 |

2.2 Diesel Construction Equipment Population Growth Surrogates⁷

The TexN model contains 25 distinct “sectors” with distinct equipment population and activity profiles. Diesel construction equipment (DCE) comprises most of these “sectors”. Two “sectors” within TexN, being miscellaneous equipment having less than 25 horsepower and all non-DCE, use the default profiles from EPA’s NONROAD model. The remaining 23 of these sectors represent independent DCE profiles developed specifically for the TCEQ and the TexN model under numerous projects funded by the TCEQ. The TCEQ has focused on DCE specifically, as DCE has the single largest impact on total NOx emissions from all nonroad mobile equipment represented within the model, which is a driving precursor to ozone formation. Table 7 presents a summary of the growth surrogates applied to a 2012 base-year population to forecast equipment population for each of the DCE subsectors.

Table 7. DCE Growth Surrogates

| Non-DCE* | NONROAD default |
|--|--|
| DCE - Agricultural Activities | 2012 Texas Agricultural Census |
| DCE – Boring & Drilling Equipment | Economy.com |
| DCE – Brick & Stone Operations | Economy.com |
| DCE – City and County Road Construction | Texas State Data Center county-level census population |
| DCE – Commercial Construction | Economy.com |
| DCE – Concrete Operations | Economy.com |
| DCE – County-Owned Construction Equipment | Texas State Data Center county-level census population |
| DCE – Cranes | Economy.com |
| DCE – Heavy-Highway Construction | Annual highway expenditures from the Texas Comptroller’s Office, for the period 2007 – 2013, appended the data to the 1998-2006 dataset normalized to 1998 dollars using the Consumer Price Index (CPI); Economy.com data prior to 1998 and after 2013 |
| DCE – Landfill Operations | Texas State Data Center county-level census population |
| DCE – Landscaping Activities | Tx REMI model outputs up to 2013; Texas State Data Center census population data for 2014-2050 |
| DCE – Manufacturing Operations | Economy.com |
| DCE – Municipal-Owned Construction Equipment | Texas State Data Center county-level census population |
| DCE – Transportation/Sales/Services | Economy.com |

⁷ Eastern Research Group, Texas NONROAD Model Update and Enhancement, Work Order No. 582-11-99776-FY14-25, July 30, 2014.

| Non-DCE* | NONROAD default |
|---|--|
| DCE – Residential Construction | County-level housing permit data from the Texas A&M Real Estate Center for 1980 through 2013; County-level census projections from the Texas State Data Center for 2014 through 2050; Housing start for the southern region of the country from the U.S. Census Bureau prior to 1980 |
| DCE – Rough Terrain Forklifts | Economy.com |
| DCE – Scrap Recycling Operations | Tx REMI model outputs up to 2013; Texas State Data Center census population data for 2014-2050 |
| DCE – Skid Steer Loaders | Equipment Data Associates Sales |
| DCE – Special Trades Construction | Economy.com |
| DCE – Trenchers | Economy.com |
| DCE – TxDOT Construction Equipment* | Zero growth per TxDOT Equipment Replacement Policy |
| DCE – Utility Construction | Economy.com |
| DCE – Mining & Quarry Operations | Economy.com |
| Off-road tractors, Miscellaneous , and all Equipment < 25 hp* | NONROAD default |

2.3 Meteorological Data⁸

TexN utilizes high, low and average temperature data, primarily to calculate evaporative emissions from gasoline engines. These data are required as part of TexN’s primary input file. In addition, related data on relative humidity and atmospheric pressure are used during post-processing of the TexN model outputs to adjust diesel NOx emissions for ambient effects. The TexN meteorological data is based on historical climate data from December 1996 through June 2014 from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) (http://cdo.ncdc.noaa.gov/qcled_ascii/).

2.4 Fuel Property Data

In order to maintain a high confidence level in the fuel parameters used in the development of emission inventories, trend analysis and control strategy analysis, the TCEQ has undertaken a program to periodically collect and analyze fuel samples. The data ensures the accuracy of local specific fuel information and also provides the best data available to be used in analyses to support Texas State Implementation Plan (SIP) and control strategy development. The latest fuel sampling data, conducted in the summer of 2014⁹, was incorporated into TexN for this modeling effort.

⁸ Eastern Research Group, Texas NONROAD Model Update and Enhancement, Work Order No. 582-11-99776-FY14-25, July 30, 2014.

⁹ Eastern Research Group, 2014 Summer Fuel Field Study (Revised), prepared for Texas Commission on Environmental Health (TCEQ), Revised January 2015.

2.5 Emission Factors and Control Phase-In¹⁰

The TexN model uses the default emission factor and technology type files provided with US EPA NONROAD model, thus using the same phase-in schedule and emission factors for Federal controls. However, unlike the NONROAD model which does not estimate ammonia emissions, there are four ammonia emission factors in TexN: one for diesel engines, one for spark ignition engines (gasoline and gaseous fuel) without three-way catalysts (TWCs), one for gasoline engines with TWCs, and one for natural gas/LPG engines with TWCs. For more information on how these emission factors were derived, please refer to the TexN User's Guide (2008) and the Addendum (2009)¹¹.

2.6 Post Processing Adjustments and Additional Controls¹²

TexN applies adjustment factors to the emissions estimates in the output files to generate the final criteria pollutant and ammonia emissions values. Post-processing applies county specific adjustments to emissions estimates for the appropriate SCCs. Depending upon the SCC and county, the following adjustments may be applied within the database:

- County and year specific temperature and humidity adjustments for NOx emissions;
- Adjustments for Texas Low Emission Diesel (TxLED) impacts;
- Altitude, correcting for decreased engine efficiency at increasing elevation;
- Soil compaction, reflecting relative ease or difficulty digging;
- Ground cover, reflecting relative ease or difficulty in land-clearing activity; and
- Reformulated gasoline.

3.0 Emissions Estimation

Using the latest version of the Texas NONROAD (TexN) model¹³, which incorporates all of the latest available data updates, ERG developed both controlled and uncontrolled average summer weekday emissions for VOC and NOX for the analysis years 2012, 2014, 2017, 2020, 2023, 2026, and 2028 for the DFW nine-county and HGB eight-county 1997 eight-hour ozone nonattainment areas.

¹⁰ Information taken from TexN User's Guide unless otherwise noted. *Eastern Research Group, Texas NONROAD (TexN) Model Version 1.0 User's Guide, Work Order No. 582-7-84003-FY-08-09, August 18, 2008.*

¹¹ Eastern Research Group, Deliverable 6 – Update of TexN User's Guide Addendum, Work Order No. 582-7-84003-FY09-19, July 31, 2009.

¹² Information taken from TexN User's Guide unless otherwise noted. *Eastern Research Group, Texas NONROAD (TexN) Model Version 1.0 User's Guide, Work Order No. 582-7-84003-FY-08-09, August 18, 2008.*

¹³ TexN version 1.7.1

3.1 Controlled Emissions Estimates

The controlled emissions estimates reflect the following state and federal controls:

- Small Spark Ignition Rule - Phase I (Federal),
- Small Spark Ignition Rule - Phase 2 (Federal),
- Large Spark Ignition Rule (Federal),
- Small Spark Ignition/Spark Ignition Marine Rule (Federal),
- Diesel Recreation Marine Rule (Federal),
- Tier 1 Diesel Rule (Federal),
- Tier 2/3 Diesel Rule (Federal),
- Tier 4 Diesel Rule (Federal),
- Texas Low Emission Diesel Requirements (State), and
- Reformulated Gasoline Requirements (State).

The resulting controlled emission estimates for a typical ozone season weekday for multiple years for each area are summarized in Tables 8 – 13.

Table 8. NO_x Controlled Emission Estimates – DFW 4-County Area (Tons Per Day)

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Collin | 7.59 | 7.08 | 5.95 | 4.86 | 4.18 | 3.73 | 3.53 |
| Dallas | 25.40 | 22.35 | 17.99 | 14.68 | 12.88 | 11.88 | 11.51 |
| Denton | 5.19 | 4.54 | 3.62 | 3.01 | 2.72 | 2.59 | 2.56 |
| Tarrant | 14.58 | 12.84 | 10.20 | 8.24 | 7.13 | 6.49 | 6.24 |
| Grand Total | 52.75 | 46.81 | 37.77 | 30.79 | 26.91 | 24.69 | 23.84 |

Table 9. VOC Controlled Emission Estimates – DFW 4-County Area (Tons Per Day)

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Collin | 5.19 | 4.62 | 4.13 | 3.90 | 3.85 | 3.87 | 3.91 |
| Dallas | 18.50 | 15.96 | 14.12 | 13.46 | 13.47 | 13.72 | 13.96 |
| Denton | 3.91 | 3.38 | 2.88 | 2.62 | 2.54 | 2.52 | 2.53 |
| Tarrant | 10.06 | 8.63 | 7.47 | 7.00 | 6.94 | 7.02 | 7.13 |
| Grand Total | 37.66 | 32.59 | 28.60 | 26.99 | 26.81 | 27.13 | 27.53 |

**Table 10. NO_x Controlled Emission Estimates – DFW 9-County Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Collin | 7.59 | 7.08 | 5.95 | 4.86 | 4.18 | 3.73 | 3.53 |
| Dallas | 25.40 | 22.35 | 17.99 | 14.68 | 12.88 | 11.88 | 11.51 |
| Denton | 5.19 | 4.54 | 3.62 | 3.01 | 2.72 | 2.59 | 2.56 |
| Ellis | 2.66 | 2.44 | 1.95 | 1.50 | 1.25 | 1.08 | 1.01 |
| Johnson | 2.57 | 2.26 | 1.66 | 1.24 | 1.03 | 0.92 | 0.88 |
| Kaufman | 2.60 | 2.09 | 1.56 | 1.18 | 0.98 | 0.88 | 0.85 |
| Parker | 2.08 | 1.70 | 1.25 | 0.94 | 0.78 | 0.70 | 0.68 |
| Rockwall | 0.84 | 0.77 | 0.65 | 0.53 | 0.45 | 0.41 | 0.39 |
| Tarrant | 14.58 | 12.84 | 10.20 | 8.24 | 7.13 | 6.49 | 6.24 |
| Grand Total | 63.50 | 56.08 | 44.82 | 36.18 | 31.40 | 28.69 | 27.64 |

**Table 11. VOC Controlled Emission Estimates – DFW 9-County Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Collin | 5.19 | 4.62 | 4.13 | 3.90 | 3.85 | 3.87 | 3.91 |
| Dallas | 18.50 | 15.96 | 14.12 | 13.46 | 13.47 | 13.72 | 13.96 |
| Denton | 3.91 | 3.38 | 2.88 | 2.62 | 2.54 | 2.52 | 2.53 |
| Ellis | 1.37 | 1.21 | 1.02 | 0.90 | 0.86 | 0.84 | 0.84 |
| Johnson | 0.79 | 0.69 | 0.60 | 0.56 | 0.55 | 0.55 | 0.56 |
| Kaufman | 0.94 | 0.82 | 0.72 | 0.67 | 0.66 | 0.66 | 0.67 |
| Parker | 0.99 | 0.89 | 0.76 | 0.69 | 0.67 | 0.66 | 0.67 |
| Rockwall | 1.03 | 0.90 | 0.76 | 0.66 | 0.60 | 0.57 | 0.56 |
| Tarrant | 10.06 | 8.63 | 7.47 | 7.00 | 6.94 | 7.02 | 7.13 |
| Grand Total | 42.78 | 37.10 | 32.47 | 30.47 | 30.14 | 30.42 | 30.82 |

**Table 12. NO_x Controlled Emission Estimates – HGB Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Brazoria | 3.24 | 2.84 | 2.25 | 1.76 | 1.49 | 1.35 | 1.29 |
| Chambers | 0.75 | 0.62 | 0.47 | 0.36 | 0.31 | 0.29 | 0.28 |
| Fort Bend | 3.86 | 3.61 | 2.95 | 2.34 | 2.00 | 1.79 | 1.70 |
| Galveston | 2.39 | 2.08 | 1.67 | 1.30 | 1.09 | 0.97 | 0.91 |
| Harris | 36.67 | 32.26 | 25.36 | 20.04 | 17.24 | 15.70 | 15.14 |
| Liberty | 1.10 | 0.92 | 0.68 | 0.51 | 0.42 | 0.38 | 0.36 |
| Montgomery | 3.05 | 2.66 | 2.12 | 1.67 | 1.42 | 1.29 | 1.24 |
| Waller | 0.81 | 0.69 | 0.51 | 0.39 | 0.33 | 0.30 | 0.29 |
| Grand Total | 51.88 | 45.68 | 36.01 | 28.36 | 24.30 | 22.06 | 21.21 |

**Table 13. VOC Controlled Emission Estimates – HGB Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Brazoria | 2.67 | 2.34 | 1.94 | 1.69 | 1.56 | 1.49 | 1.46 |
| Chambers | 0.89 | 0.78 | 0.62 | 0.50 | 0.44 | 0.39 | 0.37 |
| Fort Bend | 2.07 | 1.86 | 1.68 | 1.61 | 1.61 | 1.64 | 1.67 |
| Galveston | 3.08 | 2.70 | 2.26 | 1.95 | 1.78 | 1.67 | 1.63 |
| Harris | 26.09 | 22.69 | 19.39 | 17.80 | 17.36 | 17.35 | 17.51 |
| Liberty | 0.51 | 0.46 | 0.40 | 0.37 | 0.36 | 0.37 | 0.37 |
| Montgomery | 3.69 | 3.29 | 2.82 | 2.52 | 2.38 | 2.32 | 2.30 |
| Waller | 0.38 | 0.34 | 0.30 | 0.27 | 0.26 | 0.26 | 0.26 |
| Grand Total | 39.38 | 34.45 | 29.40 | 26.71 | 25.75 | 25.49 | 25.57 |

3.2 Uncontrolled Emissions Estimates

To estimate the uncontrolled emissions using TexN, the Technology Type Year was set to 1970, essentially turning off all Federal controls. In addition, the State controls for TxLED and RFG were also turned off. The resulting emissions are presented in Tables 14-19.

**Table 14. NO_x Uncontrolled Emission Estimates – DFW 4-County Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Collin | 19.43 | 21.60 | 24.26 | 25.74 | 27.22 | 28.52 | 29.45 |
| Dallas | 60.13 | 65.10 | 71.72 | 74.79 | 77.97 | 80.68 | 82.61 |
| Denton | 12.69 | 13.67 | 15.16 | 16.15 | 17.19 | 18.22 | 18.97 |
| Tarrant | 35.90 | 38.85 | 42.32 | 44.17 | 46.09 | 47.78 | 48.94 |
| Grand Total | 128.15 | 139.23 | 153.46 | 160.85 | 168.46 | 175.21 | 179.97 |

**Table 15. VOC Uncontrolled Emission Estimates – DFW 4-County Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Collin | 16.06 | 16.78 | 17.76 | 18.55 | 19.33 | 20.09 | 20.61 |
| Dallas | 57.82 | 60.50 | 64.29 | 67.35 | 70.44 | 73.44 | 75.47 |
| Denton | 10.82 | 11.27 | 11.91 | 12.44 | 12.96 | 13.48 | 13.83 |
| Tarrant | 30.15 | 31.49 | 33.33 | 34.85 | 36.38 | 37.87 | 38.88 |
| Grand Total | 114.85 | 120.04 | 127.29 | 133.18 | 139.12 | 144.88 | 148.78 |

**Table 16. NO_x Uncontrolled Emission Estimates – DFW 9-County Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Collin | 19.43 | 21.60 | 24.26 | 25.74 | 27.22 | 28.52 | 29.45 |
| Dallas | 60.13 | 65.10 | 71.72 | 74.79 | 77.97 | 80.68 | 82.61 |
| Denton | 12.69 | 13.67 | 15.16 | 16.15 | 17.19 | 18.22 | 18.97 |
| Ellis | 7.19 | 8.30 | 9.34 | 9.75 | 10.19 | 10.53 | 10.76 |
| Johnson | 7.64 | 8.38 | 8.90 | 9.19 | 9.50 | 9.82 | 10.03 |
| Kaufman | 7.79 | 7.73 | 8.35 | 8.80 | 9.27 | 9.75 | 10.09 |
| Parker | 6.42 | 6.42 | 6.86 | 7.18 | 7.51 | 7.85 | 8.10 |
| Rockwall | 2.11 | 2.33 | 2.62 | 2.80 | 2.99 | 3.17 | 3.31 |
| Tarrant | 35.90 | 38.85 | 42.32 | 44.17 | 46.09 | 47.78 | 48.94 |
| Grand Total | 159.30 | 172.37 | 189.53 | 198.57 | 207.93 | 216.33 | 222.25 |

**Table 17. VOC Uncontrolled Emission Estimates – DFW 9-County Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Collin | 16.06 | 16.78 | 17.76 | 18.55 | 19.33 | 20.09 | 20.61 |
| Dallas | 57.82 | 60.50 | 64.29 | 67.35 | 70.44 | 73.44 | 75.47 |
| Denton | 10.82 | 11.27 | 11.91 | 12.44 | 12.96 | 13.48 | 13.83 |
| Ellis | 3.55 | 3.78 | 4.03 | 4.19 | 4.35 | 4.50 | 4.60 |
| Johnson | 2.87 | 3.05 | 3.22 | 3.36 | 3.50 | 3.63 | 3.73 |
| Kaufman | 3.14 | 3.24 | 3.43 | 3.59 | 3.75 | 3.90 | 4.01 |
| Parker | 2.82 | 2.93 | 3.10 | 3.23 | 3.35 | 3.48 | 3.56 |
| Rockwall | 2.55 | 2.63 | 2.75 | 2.85 | 2.96 | 3.06 | 3.13 |
| Tarrant | 30.15 | 31.49 | 33.33 | 34.85 | 36.38 | 37.87 | 38.88 |
| Grand Total | 129.79 | 135.67 | 143.82 | 150.40 | 157.03 | 163.46 | 167.81 |

**Table 18. NO_x Uncontrolled Emission Estimates – HGB Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Brazoria | 8.74 | 9.36 | 10.26 | 10.64 | 11.08 | 11.48 | 11.74 |
| Chambers | 2.10 | 2.18 | 2.33 | 2.44 | 2.57 | 2.69 | 2.77 |
| Fort Bend | 10.21 | 11.48 | 12.70 | 13.29 | 14.00 | 14.66 | 15.11 |
| Galveston | 6.33 | 6.70 | 7.38 | 7.55 | 7.74 | 7.90 | 8.02 |
| Harris | 93.60 | 102.60 | 112.36 | 116.37 | 121.24 | 125.65 | 128.71 |
| Liberty | 3.34 | 3.44 | 3.65 | 3.75 | 3.88 | 4.00 | 4.08 |
| Montgomery | 7.95 | 8.54 | 9.39 | 9.80 | 10.27 | 10.71 | 11.01 |
| Waller | 2.48 | 2.56 | 2.73 | 2.86 | 2.99 | 3.13 | 3.21 |
| Grand Total | 134.74 | 146.85 | 160.80 | 166.70 | 173.76 | 180.21 | 184.67 |

**Table 19. VOC Uncontrolled Emission Estimates – HGB Area
(Tons Per Day)**

| County | 2012 | 2014 | 2017 | 2020 | 2023 | 2026 | 2028 |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Brazoria | 6.81 | 7.07 | 7.43 | 7.69 | 7.95 | 8.21 | 8.38 |
| Chambers | 1.82 | 1.87 | 1.94 | 2.00 | 2.06 | 2.12 | 2.16 |
| Fort Bend | 6.97 | 7.36 | 7.85 | 8.22 | 8.61 | 8.98 | 9.24 |
| Galveston | 6.79 | 7.00 | 7.32 | 7.56 | 7.79 | 8.02 | 8.18 |
| Harris | 76.65 | 80.32 | 85.22 | 89.00 | 92.94 | 96.79 | 99.36 |
| Liberty | 1.54 | 1.61 | 1.70 | 1.78 | 1.85 | 1.92 | 1.97 |
| Montgomery | 8.99 | 9.32 | 9.80 | 10.18 | 10.56 | 10.92 | 11.16 |
| Waller | 1.20 | 1.25 | 1.32 | 1.37 | 1.43 | 1.48 | 1.52 |
| Grand Total | 110.76 | 115.80 | 122.58 | 127.79 | 133.19 | 138.45 | 141.97 |

3.3 Trends

The following figures illustrate the trends for controlled emissions in the DFW and HGB areas.

Figure 1. DFW Controlled Emissions Trends (NO_x) (Tons Per Day)

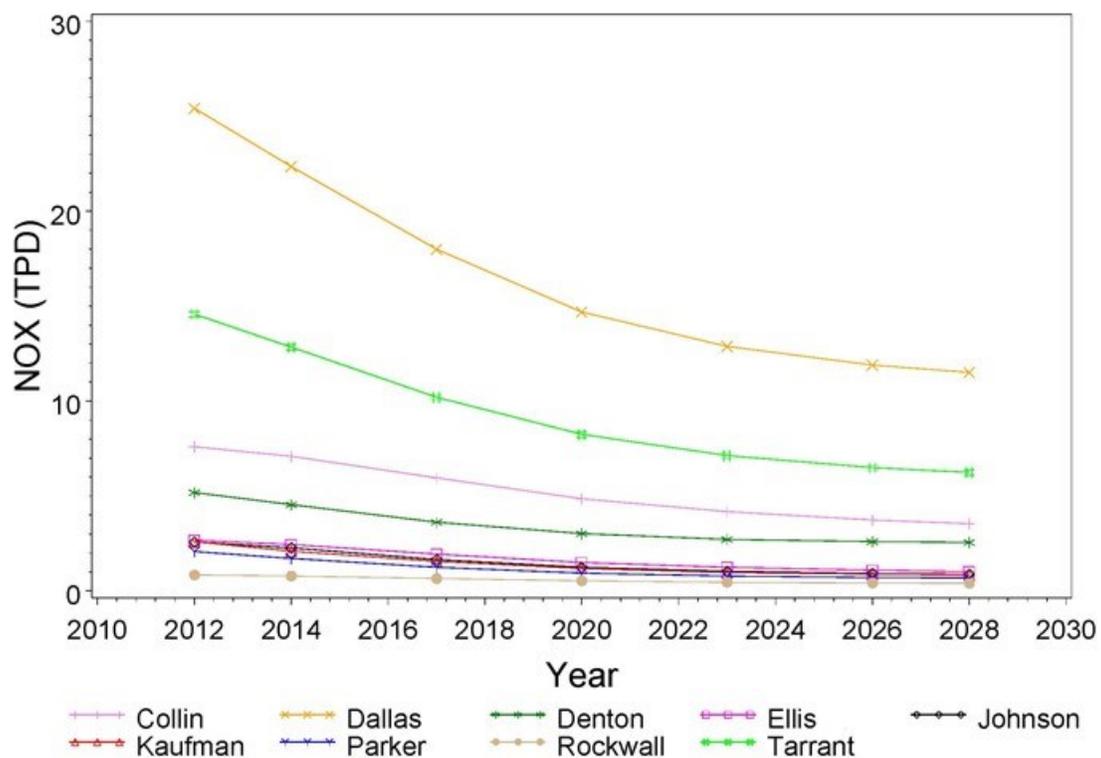


Figure 2. DFW Controlled Emissions Trends (VOC) (Tons Per Day)

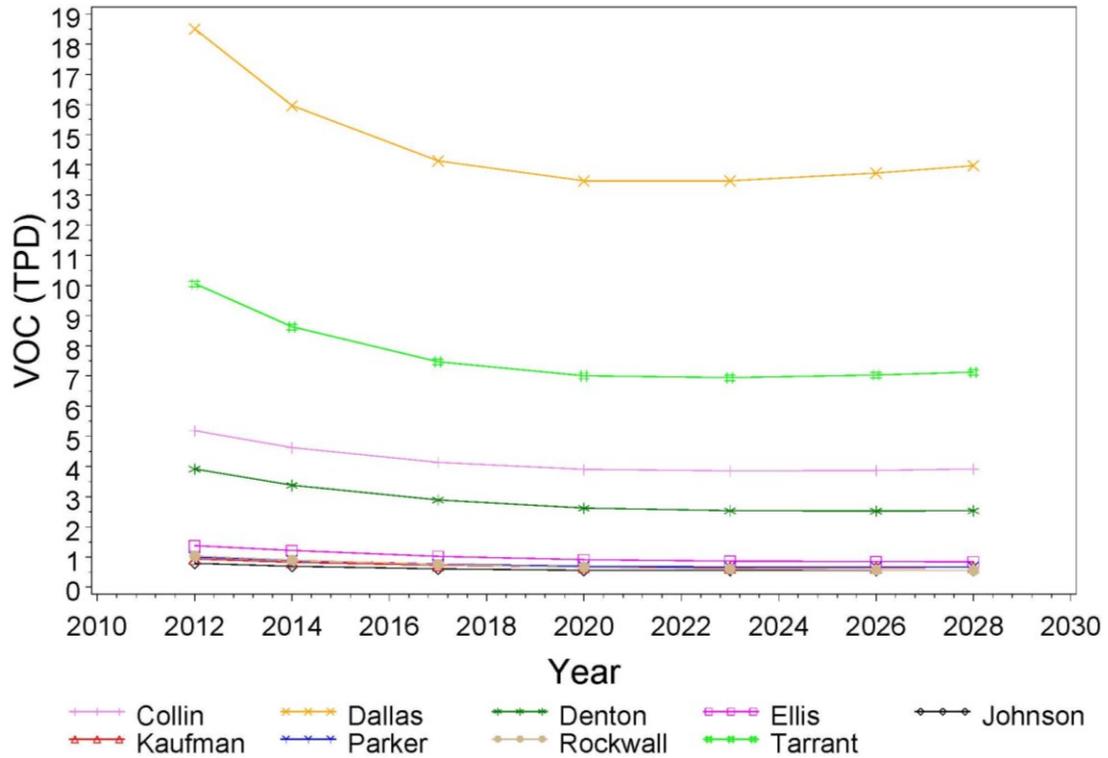


Figure 3. HGB Controlled Emissions Trends (NO_x) (Tons Per Day)

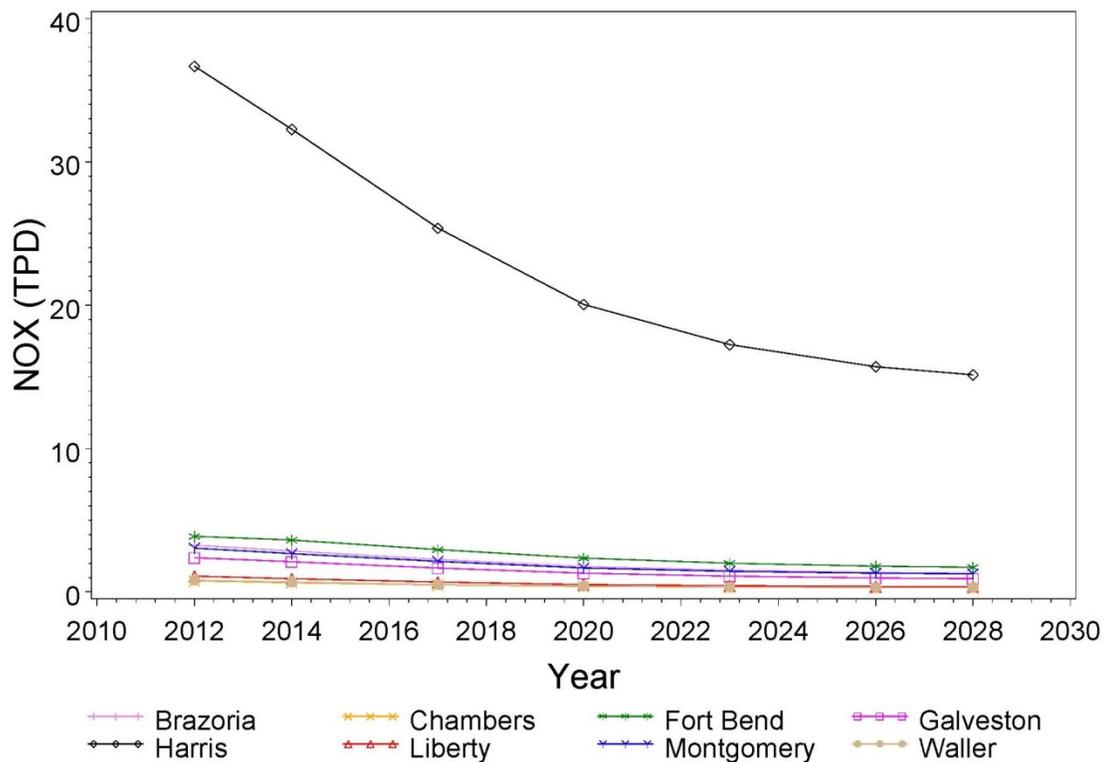


Figure 4. HGB Controlled Emissions Trends (VOC) (Tons Per Day)

